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START 4 - REGION 8

TECHNICAL MEMORANDUM

TO: Steve Way, EPA Region 8 On-Scene Coordinator

FROM: Jan Christner, Superfund Technical Assessment and Response Team (START4)

DATE: June 4, 2014

SUBJECT: Rico Argentine St. Louis Tunnel Site, Rico, Dolores County, Colorado. Review of *Evaluation of Source Water Controls*, Prepared for Atlantic Richfield Company by AMEC Environment & Infrastructure, Inc.

The United States Environmental Protection Agency (EPA) tasked the Weston Solutions, Inc., (WESTON) Superfund Technical Assessment and Response Team 4 (START4) under Technical Direction Document (TDD) #1306-07 to support U.S. EPA's efforts at the Rico Argentine St. Louis Tunnel site in Rico, Dolores County, Colorado. This memo provides a review of *Evaluation of Source Water Controls,* submitted by Atlantic Richfield Company (AR) to EPA on December 31, 2014. The Evaluation of Source Water Controls provides an overview of the mine workings, discussion of water flow and contaminant concentrations in various segments of the workings, a limited list of potential hydraulic control methods, potential contaminant controls, and recommendations.

The primary comments to the source water control evaluation are:

1. The historic information has not been thoroughly compiled or summarized and thus there is an incomplete and/or unsubstantiated description of the mine workings and flow paths. The only detailed information provided is for the Blaine Tunnel near the Humboldt Drift and the 517 Shaft. A compilation and brief summary of current and historic documents that provide additional information regarding the mine workings, mine water flow, and mine water quality should be provided.

2. The range of alternatives that were considered for source water controls and the rationale presented for eliminating alternatives was limited. The source water control alternatives that were considered and the rationale for determining the applicability of each should be clearly presented.

The following are specific comments regarding the *Evaluation of Source Water Controls.*

Introduction (Section 1)

1. The objectives of the report are stated in Section 1.1:

   "The main objectives of this report are to summarize the available investigation data on the sources of water and contaminants that discharge from the St. Louis Tunnel and to evaluate potential methods for controlling the flow of water and/or the discharge of contaminants."

   Despite this stated objective, the report focuses on the in mine treatment study (injection test) rather than evaluation of measures that might be taken to reduce or direct the flow of water into the workings and/or reduce the mobilization of contaminants within the workings. If these items are outside the scope of this evaluation, that should be stated. Information that supports the conclusion that source water controls are not viable at this time should be presented and not just vaguely referenced.

Mine Workings (Section 2.1)

2. A value of 670,000 gallons of water backed behind the blockage under average flow conditions was cited in Section 2.1 but no calculations were provided in this report and that specific number was not found in the cited report, the Preliminary Design Report, St. Louis Tunnel Hydraulic Control Measures. This volume appears to be the average storage volume shown for Alternative 1 (current St. Louis Tunnel configuration) in Table 5.4 of the Preliminary Design Report.

3. The description of the St. Louis Tunnel and Rico-Argentine Mine workings appears incomplete given the extensive efforts in obtaining, sorting, digitizing, and reviewing historic records. It is unknown if the researched documents provide additional understanding of the workings, flow through the workings, and contaminant mobilization/transport in the workings. It would be helpful for key points and summary information to be provided in this report and for source documents to be attached to the report as digital files. Summary information might include key information about workings including tunnel lengths, grades, stability, location, and extent of raises/winzes/stopes, inventory of the current status of portals, vertical extent of the Number 3 Shaft, etc. This information would be particularly useful if something occurs that changes the conditions within the workings. In the future, based on the AMEC report analysis, it might become important to better understand the NW Cross-cut area mines. It would be a waste to have lost the knowledge gained from recent research and have to go through the historic records again at that time.

    a. Attachment 1, AECOM Mine Workings Figures, Figures 2, 3, and 4 show the maps and file names from which the figures were made. EPA may have been provided some or all of the documents in the past, but this report should provide the current state of knowledge regarding the mine workings, and thus the source documents should be attached or the location of the source documents should be noted.

    b. Some of these items may be less important given the current inaccessibility of the mine workings.

4. The source for the estimation of the length of the Cross-cut that is within or adjacent to the Blackhawk fault is not provided.

St. Louis Tunnel Discharge Rates and Water Sources (Section 2.2)

5. From Section 2.2, 1st paragraph:

> "The relatively constant base flow of well-mixed, clean groundwater is apparently augmented by more contaminated flows that infiltrate into the mine workings during spring runoff (URS, 2012)."

This sentence appears to imply that water is contaminated before it enters the mine and that the contaminated water only infiltrates during spring runoff. The sentence slightly changes the meaning from the text in the 2011 Source Water Investigation Report:

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> *The St. Louis Tunnel shows an opposite trend than the mine waters and Silver Creek. Concentrations generally increase during spring and early summer, then decrease during periods of lower flow (Table 15). This may be an indication that as spring runoff flows into the Rico-Argentine mine and other sources, the flow contribution from these contaminated sources increases relative to the more constant base flow of cleaner groundwater that feeds the St. Louis Tunnel.*

There is no data to indicate that the contaminated water only flows to the St. Louis Tunnel during spring runoff or that the water flowing into the mine workings is contaminated prior to entering the mine. While some mineralization of the water flowing into the workings may occur with infiltration through metal-rich features (fractures, faults) prior to entering the workings, it is clearly understood that water becomes contaminated within the workings via contact with exposed metal rich surfaces.

6. This is the first formal presentation of the historic memos that present concentrations and relative flow rates from the NW Cross-cut, SE Cross-cut, 145 Raise, and St. Louis Tunnel during August 1980. This document relies heavily on that information. While it makes sense to consider the information, conclusions should be very cautious as the relative flows were estimates, they may not reflect seasonal conditions during that time, and they may not reflect current conditions at all.

    a. The difference between Sample #3, Total Discharge – St. Louis Portal, and Sample #9, shown on the data report as St. Louis Adit Discharge, is unknown. It is possible that one was a duplicate sample or that one was collected at the intersection of the St. Louis Tunnel and the Cross-cut and the other was collected from the actual portal.

7. The flat flow rates at the St. Louis Tunnel (DR-3) during the expected 2013 peak flow (1-2 months after peak flow in the Dolores River) were described as possible instrument error. That may be the case and should be investigated, but it is possible that either changes in the St. Louis Tunnel blockage or low flows into the tunnel caused reduced discharge.

8. Two important statements in this section should be considered when using the flow allocation data to evaluate locations for source water controls

    a. In regard to the relative contributions to St. Louis Tunnel flow from the SE Cross-cut, NW Cross-cut, and 145 Raise, the report states that flow proportions are presumed to vary seasonally, given the seasonal flow variations at DR-3 and the inferred primary precipitation infiltration source of the flows.

    b. The report also states that the flow proportions may not still be accurate.

St. Louis Tunnel Contaminant Discharge and Contributions (Section 2.3)

9. The relative mass of contaminants contributed by the NW Cross-cut, SE Cross-Cut, and 145 Raise during August 1980 is presented. Given the total metals concentrations and estimated flows from 1980, it appears that significantly more cadmium and zinc were contributed from the NW Cross-cut than from the SE Cross-cut. During previous discussions with AR, the information was discounted as a rough estimate and not necessarily consistent with other site data or representative of current conditions. This affected the approach to investigating the mine workings and should be discussed to some degree.

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10. The report notes that the mass balance at the intersection of the Cross-cut and St. Louis Tunnel does not balance using the given numbers. For example, using 1980 zinc concentrations of 27 mg/L in the NW Cross-cut, 2.62 mg/L in the SE Cross-cut, 0.5 in the 145 Raise area, and 5.2 mg/L in the St. Louis Tunnel discharge and flow percentages of 25%, 67%, 8% and 100%, respectively, the mass balance is:

$$27 * 25\% + 2.62 * 67\% + 0.5 * 8\% = 5.2 * 100\%$$

$$8.54 \neq 5.2$$

In other words, mass loading in the St. Louis Tunnel discharge was less than the sum of the loads from the contributing three locations. Two methods were used to balance the equation.

A. First, it was assumed that the flow estimates were incorrect but that the concentration values were valid. The mass balance was re-calculated by varying the flow percentages contributed by each source. This was done for all of the contaminants, not just zinc, and the best fit flow estimates that make the masses balance are shown in the "adjusted flow estimate" column below. The result shows a much greater contribution of flow from the SE Cross-cut than originally estimated.

B. Second, it was assumed that the St. Louis Tunnel discharge was measured at the portal and that the St. Louis Tunnel sample was diluted by water infiltrating the tunnel between the intersection of the Cross-cut and the St. Louis Tunnel and the St. Louis Tunnel portal, and that the concentration of inflow water was the same as water from the 145 Raise area. This calculation results show that an estimated 42% of St. Louis Tunnel discharge is from inflow of "clean" water into the tunnel between the point of intersection with the Cross-cut and the portal. (The text states 40% but the calculated values show 42%).

   a. The footnote on page 5, section 2.2, states that "undated geologic mapping of the main St. Louis Tunnel believed to have been prepared in the mid- to late-1950s identified minor seepage in a few locations. Based on the detail and nature of the mapping, it is believed that the existence of major groundwater inflows would have been noted in the mapping." Therefore, the assumption that the difference in load between the sum of the sources and the St. Louis Tunnel is due to infiltration of water within the tunnel may not be realistic.

The 1980 flows and zinc load contributions from each location and the flows and loads calculated using the two methods described above are shown on the following tables.

Location	1980 Flow Estimate	Adjusted Flow Estimate	Assuming Dilution in SLT
SE Cross-cut	67%	82%	39%
NW Cross-cut	25%	12%	15%
145 Raise	8%	6%	<5%
SLT Inflow	--	--	42%

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Location	1980 Zinc Load	Adjusted Zinc Load	Zinc Load Assuming Dilution in SLT
SE Cross-cut	79%	59.8%	76.4%
NW Cross-cut	20.5%	39.6%	18.9%
145 Raise	<1%	<1%	<1%
SLT Inflow	--	--	3.9%

Other possible reasons for discrepancies in flows and loading not accounted for in these calculations are:

- Contaminants are attenuated in the St. Louis Tunnel. This is less likely because fluoride is not expected to attenuate, but the mass balance shows "extra" fluoride in the source (NW Cross-cut, SE Cross-cut, and 145 Raise) samples relative to the St. Louis Tunnel sample.
- Laboratory analyses were incorrect. This is less likely to account for the differences due to the consistencies among the different contaminants measured, even fluoride.
- Inconsistencies in sample collection such that more high-metal solids were collected in one sample than in the others, resulting in greater contaminant concentrations in the total metals analytical result.

11. The statements presented in the report suggest that the available information indicates that the NW Cross-cut contributed more of the contaminant load than the SE Cross-cut and the 145 Raise area. While it is questionable if this is a valid conclusion, the report needs to provide the rationale for not investigating the mines in Telescope Mountain. Potential reasons for not investigating these mines are inaccessibility, private property concerns, or the 1985 memo presented in Attachment 2 that states: "The highest flow of dirty water is out of the NW Cross-cut, and we can do nothing about it that I can recommend." This provides some indication that even if the St. Louis Tunnel was accessible, it may not be possible to reduce the loading of contaminants from the NW Cross-cut. Additional comments to follow explain why this conclusion about loads from the NW Cross-cut may not be supported by the currently available data.

Blaine Tunnel Source Area (Section 2.4)

12. Information regarding the Blaine Tunnel that was not provided in the description of Mine workings in Section 2.1 is provided in Section 2.4. The length of the tunnel, faults that intersect the tunnel, potential sources of inflow, former discharges to Silver Creek and subsequent diversion of water to the St. Louis Tunnel, recent water diversions, outflow locations, recent mine improvements, and recent water quality are described. Detailed information is only provided for the portion of the Blaine Tunnel near the portal that was investigated during 2011. At least one critical flow path (Number 3 Shaft) is present beyond the described area, and others may exist. It would be good to know if there are other details about the Blaine Tunnel regarding the "other interconnected drifts, inclines, and stopes" that potentially provide additional flow paths to the lower mine workings and the SE Cross-Cut. A Burack report that we haven't seen is referenced and should be provided with other source documents.

13. Bullets highlighting concentrations of water pooled behind the coffer dam during 2011 have the total and dissolved cadmium concentrations reversed and the total and dissolved iron concentrations reversed. This doesn't affect any of the conclusions of this report.

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14. Flow at the Blaine flume is shown on Figure 2-5. The maximum flow during 2012 and 2013 has been approximately 3 gpm, with peaks in January 2013, about two months after flow was first detected, and in early October 2013. It is agreed that 2013/2014 data will supplement this data and help determine whether the peak flow through this segment of the Blaine Tunnel typically lags spring runoff by several months or whether the 2013 peaks were a result of work in the mine or other factors.

15. The report notes that water quality outby the flume consistently contained greater metal concentrations and lower pH than water inby the flume. This, plus the noted reports of water seeps both inby and outby the flume, may indicate that this section of the Blaine Tunnel receives highly contaminated water, possibly from upper mine levels such as the Argentine Tunnel.

16. The Evaluation of Source Water Controls Report does not address Blaine Tunnel water quality cited in the historic memoranda provided in Attachment 2. There is a great difference in Blaine Tunnel water quality measured at the "collar of the Blaine Shaft" in 1980 and current water quality measured both inby and outby the flume during 2011 through 2013.

    a. The Blaine Tunnel sample from 1980 contained 0.022 mg/L total cadmium and 1.78 mg/L total zinc. Concentrations in recent Blaine Tunnel samples cited in Table 2-3 of this report ranged from 1.09 mg/L to 4.48 mg/L total cadmium and from 177 mg/L to 644 mg/L total zinc. The current samples were collected near the portal while the earlier sample was reportedly collected from near the #3 shaft. The difference could be due to changes over time or the different locations sampled within the Blaine Tunnel.

    b. Comparison of the 1980 DR-3 metal concentrations to the limited number of current DR-3 metal concentrations provided in Table 2-3 show that the 1980 and current DR-3 concentrations are relatively similar. Current DR-3 concentrations provided in Table 2-3 (varying from 0.0181 mg/L to 0.024 mg/L total cadmium and from 4.05 mg/L to 4.62 mg/L total zinc) were similar to DR-3 concentrations cited in the 1980 memos (0.022 mg/L total cadmium and 5.2 mg/L total zinc).

    c. Given the low metal concentrations in the 1980 Blaine Tunnel water sample likely collected from near the Number 3 Shaft compared to more recent concentrations measured in water near the portal, it is possible that the Blaine Tunnel water samples collected from near the portal are not indicative of water located farther back into the tunnel. This is supported by comparison of two samples that were collected from the Blaine Tunnel during 1985 (see Attachment 2; memorandum dated August 27, 1985). Concentrations of cadmium and zinc in Sample B-1, collected in the Blaine Level at the diversion to lower workings (possibly meaning near the Humboldt Drift) were significantly greater than cadmium and zinc concentrations in Sample B-2, collected at the collar of the Blaine Shaft (assumed to be the Number 3 Shaft).

    d. The cause of the difference in water quality at the two locations is unknown; however, it is likely that the Blaine Tunnel near the Humboldt Drift receives inflows of highly contaminated water, possibly from upper levels in the mine. This is reasonable given the elevated metal concentrations measured in water observed to be flowing into the Blaine Tunnel during 2011 (measured at 1.18 mg/L dissolved cadmium, 199 mg/L zinc, and estimated 5 to 10 gpm flow). The presence of highly contaminated water in at least one of

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the upper levels was documented in the August 2011 sample collected by EPA in the Argentine Tunnel.

17. Contaminant loading from the Blaine Tunnel is addressed in Section 2.4.7 and Table 2-4. The loading of metals from the Blaine tunnel near the Humboldt Drift was calculated for April, June, July, and August 2013 sample dates using sample analytical results and the daily average flume flow on the sample date.

    a. The results indicate that while only 0.02% to 0.06% of the St. Louis Tunnel flow comes from the Blaine near the Humboldt Drift, approximately 1.5% to 10% of the cadmium and 1% to 6% of the zinc load at DR-3 could be allocated to the Blaine near the Humboldt Drift. Contaminant attenuation in the tunnel between the Blaine and DR-3 was not considered in this evaluation.

    b. The Blaine Tunnel flume flow was very low (0.03 gpm to 0.3 gpm) when the loads were calculated, but was greater during other times of year (as great as 3 gpm during January 2013 and as great as 2.8 gpm during October 2013). If Blaine Tunnel flow increased relative to the flow at the St. Louis Tunnel during certain times of the year while concentrations at the Blaine Tunnel remain the same, a more significant percentage of the load would be attributable to this portion of the mine workings. The report calculated the peak loading rate based on the peak flows (January 2013) and the greatest contaminant concentrations (April 2013). The peak loading rates were the same order of magnitude as the entire loading at the St. Louis Tunnel during the four 2013 sample events that were evaluated. The report notes that water may be diluted with cleaner inflow when flow in the Blaine tunnel is at a peak.

    c. Since inflows to the Blaine Tunnel near the Humboldt Drift may cause significant loading to the St. Louis Tunnel during high flow in the Blaine, it may be valuable to investigate potential sources of the water including the accessible mine workings above the Blaine level, particularly the Argentine Tunnel.

18. Other documents regarding historic Blaine Tunnel concentrations and flows were not provided or discussed. For example, a peak flow from the Blaine Tunnel of 400 gpm was discussed by AR when planning the 2011 and 2012 Blaine Tunnel work. The source of this information isn't cited and related water quality data is not available.

Other Source Areas (Section 2.5)

19. The only detailed information is the Argentine Tunnel workings data from EPA's August 2011 entry and sampling.

20. Water collected from the Argentine Tunnel in August 2011 contained very high concentrations of cadmium and zinc. If there is a simple means to prevent contact with source materials in the Argentine Tunnel, it might be worth the effort to investigate.

21. Section 2.5.2 states that historic maps are available for the upper workings that are not mapped in this report. No mapping is provided above the Blaine (100) Level. As noted above, the documents that contain information regarding the upper workings should be provided in the electronic archive and referenced in this report. Maps from the upper mines could be helpful in the future if

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there is a need due to a change in conditions at the site such as those that occurred in the Blaine adit, and or to do further investigation to reduce the flow of contaminants from the upper workings to the St. Louis Tunnel or to Silver Creek.

Source Water Hydraulic Control (Section 3)

22. This section is very brief and doesn't really discuss specific hydraulic control measures and how they might be applicable to the site. The listing of methods is limited to:

> "This section briefly considers potential methods (e.g., plugging tunnels or grouting fractures) for reducing the mine water discharge rate at the St. Louis Tunnel portal by controlling the flow of water within in the mine workings. Conceptually, reducing flow of mine water is one method for reducing the rate of contaminant discharge from the St. Louis Tunnel portal."

23. The analysis is based on the flow and load reductions that might be seen assuming the 1980 flow and loading data is accurate.

24. The potential for reducing inflow to the mine working from Silver Creek was not addressed. The report acknowledges in Section 2.2 that the results of the tracer study showed a loss of flow from Silver Creek in the area near the Blaine Tunnel; however, lining Silver Creek in the vicinity of the Blackhawk Fault and various mine workings was not considered or evaluated in the report. While the contribution of water from Silver Creek to the mine workings was not quantified or confirmed during EPA's 2011 tracer testing (Section 2.2), the relative flow rates of the water lost from Silver Creek in that reach were demonstrated. This report does not attempt to relate this loss of surface flow and the potential contribution to discharge from the St. Louis Tunnel and the relative benefit or lack of benefit from reducing that loss. The rationale for not considering the option to reduce the likely flow of water into the mine should be stated. Constructing features to prevent the flow of surface water from Silver Creek into the mine workings is not subject to the same safety and accessibility limitations that were cited for potential actions with underground workings.

25. The rationale for not using hydraulic controls or elimination of contaminant mass inflows in the Blaine Tunnel is:

> "Hydraulic control of these flows or elimination of contaminant mass inflows to the Humboldt Drift would provide little benefit in reducing the overall flows or loadings at the St. Louis Tunnel and thus are not practical."

    This is not fully supported by the data.

26. The basis for estimating the amount of St. Louis Tunnel flow that comes from the workings to the south of Silver Creek is not substantiated.

> "Mine workings to the south of Silver Creek drain to the SE Cross-cut, based on historic mine maps and tracer testing conducted in 2011 (URS, 2012). These mine workings are the source of a substantial fraction (although apparently not the majority) of the flow that discharges from the St. Louis Tunnel."

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The 2011 tracer tests show connection between the Blaine Tunnel and the 517 shaft and from the 517 Shaft to the St. Louis Tunnel. The percentage of flow cannot be determined by that test due to the injection of Silver Creek water and incomplete recovery of the injected tracer.

27. The following statement is not backed up by the referenced Section 4.

> "Based on the current understanding, the SE Cross-cut and the mine workings that drain to the SE Cross-cut are not readily or safely accessible for establishing hydraulic controls. Although methods for controlling contaminant loading from the SE Cross-cut have been investigated (as described in Section 4), the feasibility of establishing hydraulic controls in these parts of the mine workings was not part of this investigation."

Section 4 just describes the injection test but does not explain whether or how other means of controlling contaminant mobilization and transport to the St. Louis Tunnel were considered. Other means might be removal or treatment of source materials such as fine grained ore; sealing of highly mineralized ribs, floors, or stopes; or other methods to reduce mobilization and transport of contaminants from the mine workings. If the mine workings are inaccessible, these measures may not be applicable. However, this report has not considered any other contaminant controls other than chemical injection and this should be justified somewhere.

28. The discussion of the NW Cross-cut is minimal and is based on the early 1980s memos regarding flow and loading.

> "Access to the NW Cross-cut from the St. Louis Tunnel is not currently possible due to obstructions at the St. Louis Tunnel portal area, and access from other mine workings to the north of the St. Louis Tunnel has not been assessed. The feasibility of establishing hydraulic controls in the mine workings to the north of the St. Louis Tunnel was not part of this investigation; thus, the potential for reducing or controlling flows and/or contaminants that are contributed by the NW Cross-cut cannot be assessed at this time."

It is agreed that hydraulic controls in the NW Cross-cut from the St. Louis Tunnel portal are not viable at this time but might be feasible at a later time if the St. Louis Tunnel is opened in the future. (See comment above regarding historic conclusion regarding controlling NW Cross-cut flows and contaminants.) More information regarding this section of the mine workings would help justify this conclusion.

29. The rationale for not considering hydraulic controls from within the workings to eliminate inflow from the 145 raise is reasonable given the inaccessibility of the raise area at this time. However, there is no discussion of the option to determine if water infiltration from the surface is a contributor to the flows from the raise. The mine mapping data would allow projection of the location of ground surface above the raise so it can be inspected to determine if the topography and geology are conducive to directing water into the raise. This information must be provided in the report, or provide an explanation as to why it not provided. If a raise actually extends to or near the surface, there may be means to reduce the inflow of water from the surface or near surface if the terrain allows safe access.

30. The poor cost:benefit ratio of performing evaluations in recently un-accessed segments of the mine workings is the best rationale stated for not pursuing hydraulic controls. Even with safe access, substantial investigations would be needed to determine feasible locations and the likely

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future success or effects of hydraulic control measures. Given the likely cost of accessing these areas with no certain return on the investment and the potential for other site efforts to meet remediation goals in the long-term, the conclusion to not install hydraulic controls at this time is reasonable but may be considered at a later time if site conditions change.

31. From Section 3.5:

    "The subsurface workings that are known to be safely accessible are the 517 Shaft Access Tunnel and the near portal reach of the Blaine Tunnel."

    The Argentine Tunnel is accessible and there is no mention of an inventory of the other portals.

Source Water Contaminant Control (Section 4)

32. This section relies on injection of alkaline solutions into the 517 Shaft as the only means to control mobilization and transport of contaminants from the mine workings. This section would be improved by describing a variety of means to reduce contaminant mobilization and/or transport. For example, one of the inflows to the Blaine Tunnel showed extremely high concentrations of contaminants -- it might be worth the effort to look at mine levels above the Blaine to determine if there is a means to reduce contact between water and highly contaminating materials such as ore or muck, at least in the Argentine Tunnel since extremely high metal concentrations were found in water sampled during EPA's August 2011 entry.

33. The pH measured in the 517 Shaft water was significantly higher (pH of 5 and greater) during the 2012 geophysical characterization and prior to start of the injection test than was measured during 2011 sampling performed by EPA (pH of 2.5 to 3.5). It is unknown whether this was due to limited snowpack and run-off during 2012 or other causes.

34. The report discusses potential sludge buildup in the mine if injection were to continue for a long period of time. Estimates were made with several assumptions, including a DR-3 flow of 530 gpm, which is low given the potential values cited in the Preliminary Design Report for the St. Louis Tunnel Adit Hydraulic Control Measures Project. Regardless of the validity of the assumptions, a substantial amount of sludge would be generated in the tunnel. Since the storage capacity of the tunnel is finite, the solids may eventually require removal and disposal. The hydraulic implications of excessive sludge in the tunnel were not addressed.

35. Additional testing would be required to determine the maximum effectiveness of alkaline injection in reducing metal contaminants from the St. Louis Tunnel discharge. The effectiveness, implementability, and cost of chemical injection into the mine workings is more consistent with active treatment technology evaluation and may be more appropriately compared to other water treatment processes to determine suitability for use at this site.

Conclusions and Recommendations (Section 5)

36. The validity of the conclusions is affected by lack of information and issues presented in the comments provided above.

37. It is reasonable to not recommend further testing of in-situ chemical treatment (injection) at this time due to logistical issues, the inability to achieve anticipated effluent limits in the St. Louis

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Tunnel outflow, long-term issues with solids disposal, and more promising water treatment methods currently being evaluated to treat St. Louis Tunnel discharge.

Executive Summary

- The loading from the SE Cross-cut relative to the NW Cross-cut may be inaccurate and there is inadequate information available at this time to support the conclusion that the NW Cross-cut contributes the majority of zinc, cadmium, and manganese.

- The report has provided a reasonable case for a conclusion that hydraulic controls in the form of bulkheads within the workings are not a feasible alternative based on the current understanding of the flow paths, access and AECOM's geotechnical concerns. However, the report has overlooked the entire subject of reducing influent water to the workings from surface water infiltration.

- Chemical injection based controls may be better addressed in the water treatment alternatives evaluation.

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